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ABSTRACT

Focusing on activity preferences at home rather than activity preferences in nursery school, this study examined the relationship between preschoolers' daily activities and spatial abilities. Parents of 52 preschoolers recorded their children's home activities for 7 days. Children were given three measures of spatial ability and one vocabulary measure. Activities were categorized as being spatial, non-spatial, or undetermined, and as masculine, feminine, or neutral. Results indicated a positive relation between neutral activities (e.g. art activities, board games, swimming) and a composite spatial score for both boys and girls. Results also showed a negative relation between masculine activities (e.g. playing with action figures, playing ball, vehicles, and sports) and the composite spatial score for girls. No relation was found between spatial ability and spatial activities, and no differences were found between boys and girls on measures of spatial and verbal ability. However, boys did participate more in spatial activities. Sociocultural influences on spatial ability may be more important in explaining within-sex than between-sex variation. (Author/MM)

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Spatial Ability

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The Relation Between Preschoolers' Everyday
Activities and Spatial Ability

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Abstract

Parents of 52 preschoolers recorded their children's home activities for seven days. The children were given three measures of spatial ability and one vocabulary measure. Activities were categorized as being spatial, non-spatial, or undetermined, and as masculine, feminine, or neutral. Results indicated a positive relation between neutral activities (e.g., art activities, boardgames, swimming) and a composite spatial score for both boys and girls. In addition, there was a negative relation between masculine activities (e.g., playing with action figures, playing ball, vehicles, and sports) and the composite spatial score for girls. There was no relation between spatial ability and spatial activities. No differences were found between boys and girls on measures of spatial and verbal ability, but boys did participate more in spatial activities. Sociocultural influences on spatial ability may be more important in explaining within-sex than between-sex variation.

The Relation Between Preschooler's Everyday
Activities and Spatial Ability

It has been almost twenty years since Maccoby and Jacklin (1974) published their influential review of research on gender differences. Their conclusion that males, on the average, score higher on measures of spatial ability than females has attracted considerable attention and generated much controversy (for reviews, see Harris, 1981; Linn & Petersen, 1985; McGee, 1979; Newcombe, 1982).

According to Halpern (1986), spatial ability is defined as, "the ability to imagine what an irregular figure would look like if it were rotated in space or the ability to discern the relationship among objects." (p. 48). Linn and Petersen (1985) have argued that the construct of spatial ability is made up of three primary components: spatial perception, mental rotation, and spatial visualization. Spatial perception tasks ask individuals to determine spatial relations of objects with respect to their own body orientation, often despite distraction. Mental rotation tasks requires the comparison of two objects after the person has imagined the rotation one of the objects (see Shepard & Metzler, 1971). Spatial visualization tasks involve utilizing a multistep process where the person may employ a variety of spatial and analytic strategies in solving the spatial problem. Only spatial perception and mental rotation show sex differences, according to Linn and Petersen (1985).

Disagreements as to when sex differences in spatial ability arise are common. In their review, Maccoby and Jacklin (1974) claimed that differences in spatial ability emerged in adolescence and continued through adulthood. Others have agreed (McGee, 1979; Waber, 1977). More recently, reviewers have argued that sex differences in spatial ability can be observed earlier in development (e.g., Newcombe, 1982; Witelson & Swallow, 1988). Linn and Petersen's meta-analysis found sex differences in mental rotation from age 13 (the earliest age tested) and in spatial perception probably from age 8.

Recent empirical studies have focussed on the task of constructing spatial tests for young children that assess their spatial ability. Johnson and Meade (1987) adapted a wide variety of spatial measures and administered them to large samples of children aged 6 through 18. Their data indicated that by the age of 10 (fourth grade), males scored significantly higher on a composite spatial score than females. Furthermore, when Johnson and Meade controlled for verbal ability (as measured by reading scores) a male advantage on spatial ability appeared in the first grade. Similarly, Kerns and Berenbaum (1991) adapted measures of mental rotation and spatial visualization to be more age-appropriate and administered them to children aged 9 to 13. They found that by the age of 9 there was a significant male advantage on both measures.

The research by Johnson and Meade (1987) and Kerns and

Berenbaum (1991) shows that, using age-appropriate measures, sex differences in spatial ability can be reliably observed by the age of 9 years, and perhaps by the age of 6. Even more recently, sex differences have been observed in children as young as 4.5 years on a test devised by Huttenlocher and Levine (1993). The fact of early emergence of sex differences clearly constrains theories that aim to explain why they exist.

Currently, three theoretical views dominate the field of sex differences in spatial ability. First, sex differences can be explained in terms of biological factors. The most viable such explanations focus on the effect of variations in prenatal levels of testosterone, sometimes focussing specifically on possible associations with differences in brain lateralization (Geschwind & Galaburda, 1987; Hines & Shipley, 1984; Resnick, Berenbaum, Gottesman & Bouchard, 1986).¹

A second theoretical view suggests that sex differences in spatial ability are best explained by differences in environmental or sociocultural experiences. This view emphasizes socialization differences (Fagot, 1977; 1978) and differences in life experiences (Harper & Sanders, 1975; Newcombe, Bandura, & Taylor, 1983; Rheingold & Cook, 1975). In particular, such theories often assert that socialization practices beginning in infancy, encourage males and females to participate in different activities. Males typically play with transportation toys and building blocks, while females prefer playing with dolls, or

dress-up (Fagot, 1978). These activities are thought to differentially foster spatial ability.

A third view proposes that, sex differences in spatial ability are a result of the interaction of biological and environmental factors (Casey & Brabeck, 1990; Casey & Nuttall, 1990; Halpern, 1986). An early proponent of this explanation was Sherman (1967, 1978). Sherman hypothesized that males, due to an innate predisposition, preferred participating in activities that involved the use of spatial skills. These activities, which are stereotyped as being masculine, include block play and building models which involve the manipulation and moving of objects. Sherman hypothesized that manipulation of these type of objects allows the individual to understand the interrelatedness of the parts, as well as facilitating exploration the object from different perspectives. Females, in contrast, are thought to spend their time participating in feminine activities, such as doll play, and playing kitchen, which do not involve spatial skills.

Both Sherman and researchers espousing a sociocultural view attribute sex differences in spatial ability to differential activities played by boys and girls throughout development. They argue that masculine play activities are generally more spatial than feminine ones, and that because boys typically spend more time in these activities they score higher on spatial measures than girls. Given that sex differences in spatial ability are

evident by at least 6 years, the most relevant developmental period for examining sex differences in activity would seem to be preschool, that is, the years immediately preceding the emergence of sex differences. Yet, direct evidence on the relation of preschool activity and spatial ability is remarkably scanty.

In an often-cited study, Connor and Serbin (1977) showed that, for males only, masculine activity preferences in preschool were positively related to performance on one measure of spatial ability (WPPSI Block Design). However, reviewers of this study have often not emphasized that, on a second measure of spatial ability (Preschool Embedded Figures Test) the correlation between boys' preference for masculine activities and their performance on the test did not reach significance. Furthermore, for females, neither masculine nor feminine play preferences were correlated with either measure of spatial ability. Thus, the evidence for a correlation between sex-typing of play preferences and spatial ability is not as strong as one would like. Nor did Connor and Serbin examine directly the extent to which spatial play was related to spatial ability.

In the only other study we know examining the relation of preschool play and spatial ability, Caldera, O'Brien, Truglio, Alvarez, and Huston (1989) found, contrary to hypothesis, that teachers rated girls as preferring to play with wooden blocks, legos, and jigsaw puzzles more than boys. Rated play preferences for these activities were not related to measures of spatial

ability for either sex, and males and females did not differ on standardized measures of spatial ability.

The primary goal of the present study was to increase the very sparse data base on the theoretically crucial issue of the relation between preschoolers' daily activities and spatial ability. We used a different methodology than previous studies, focussing on activity preferences at home rather than activity preferences in nursery school. Preschoolers typically spend more time at home than at school, and the variety of activities available may be greater and less regulated by the needs of the group.

Method

Subjects

Subjects were 58 preschoolers (29 females, mean age = 56.52 months, range 46-72, and 29 males, mean age = 55.72 months, range 46-70) drawn from four preschools in the greater Philadelphia area. Approximately 30% of those parents recruited volunteered to participate with their child. Preschoolers who participated were primarily from white, middle class backgrounds. The parents of six children did not complete a journal of their children's home activities and another parent filled the journal out incorrectly. Therefore, data analysis involving preschoolers' daily activities was conducted on 51 subjects.

Materials

Preschoolers' activity journal. Parents were asked to

record their children's home activities for seven consecutive days. To structure and simplify this recording, categories of preschool activities were listed (i.e., fantasy play, art activities, outdoor games, watching tv, building games, etc.) on a daily recording sheet. Parents were asked to write down their children's activity under the appropriate category together with the amount of time spent on the activity (i.e., pretending to be Batman - 30 min, drawing pictures - 45 min).

Spatial involvement of activities. Prior to data collection, preschooler activities were categorized into one of three groups: spatial activity, non-spatial activity, and undetermined. Categorization of activities as spatial was based on previous research (Caldera, et al., 1989; Fagot & Patterson, 1969; Sherman, 1967). Spatial activities include: legos, blocks, mazes, making paper airplanes, copying pictures, vehicles, play-dough, puzzles. Non-spatial activities include: running around, watching television, fantasy play, and playing with action figures or dolls (see table 1 for a complete list). In some instances, activities reported by the parents were too vague to determine whether they were spatial or not. Examples of activities categorized as undetermined include: visiting a friend's house, and helping mom and dad. Activity journals were coded for percent of total play time devoted to the various spatial categories. Interrater reliability on the first eleven journals was .85 using Cohen's Kappa.

Sex-typed ratings of activities. To assess which preschoolers' activities are viewed as sex-stereotyped, 130 undergraduates rated the preschool activities occurring in the journals as Masculine, Feminine, or Neutral. Activities were categorized as being stereotypically masculine or feminine when at least 70% of the undergraduates rated them as masculine or feminine. Other activities were categorized as being neutral (see table 1).

Insert Table 1 about here

Activities rated by undergraduates as being stereotypically masculine and feminine were very similar to the ratings in Connor and Serbin (1977). Examples of activities rated as masculine include (top frequency activities listed): riding bikes/bigwheels, building activities, male fantasy play (e.g., pretending to be batman, teen-age mutant ninja turtles), playing with vehicles, sports. Examples of activities rated as feminine include: dolls, playing house, female fantasy play (i.e. pretending to be mom), help cleaning, playing with Barbie. Examples of activities rated as neutral include: art activities, boardgames, swimming, neutral fantasy play (i.e., pretending to be a musician), junglegym/swingset, puzzle/mazes.

The activity of watching television was categorized as neutral. However, because of the unique characteristic of

watching television, it was analyzed separately. The activity of reading or looking at books, was categorized as feminine, but was also analyzed separately.

Measures. Preschoolers were given three measures of spatial ability and one measure of verbal ability over two separate sessions while at preschool. In the first session the Block Design, Mazes, and Vocabulary subtest from the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) were administered (Wechsler, 1967). The Block Design and Mazes are viewed as measures of spatial ability, while the Vocabulary task measures verbal ability.

Block Design requires children to build a copy of a three dimensional shape using wooden blocks. In the task, an experimenter first builds an object, not allowing the child to watch how the object is constructed. Next, the geometric shape is revealed to the child. The experimenter then asks the child to use a second set of blocks and build a copy of the shape before them. The first few shapes in the Block Design are relatively easy. Subsequently, shapes increase in complexity.

The maze task is a paper and pencil measure that asks children to draw a path out of a maze. A maze could be defined as a series of interrelated passages. The goal of the task is to find a path leading out of the maze, while avoiding any paths that lead to a dead end. Like the Block Design, each new maze increases in difficulty. Both the Mazes and Block Design are

viewed as measuring the component of spatial cognition known as spatial visualization (Linn & Petersen, 1985).

The vocabulary subtest of the WPPSI ask children to give definitions of various words (i.e., what is a hat?, what is a letter?). Each new word becomes harder to define than the previous one.

On the second session individuals were given a spatial task (Puzzles) designed by Huttenlocher and Levine (1993). The Puzzle task is a new measure that has children identify a geometric shape which has been separated and rotated. Initially the child is presented with a geometric shape on a white piece of paper that has been divided in half and rotated. The experimenter asks the child to imagine putting the two shapes (two pieces of puzzle) together to form a "picture". Then, with the first piece of paper still visible, the child is presented with a second piece of paper that contains four different geometric shapes (pictures). The child is asked to point to the picture that could be made by putting the geometric shapes (puzzle pieces) together. This procedure is repeated with 32 different puzzles which become progressively more difficult. The puzzle task is believed to measure the mental rotation component of spatial ability, and show sex differences by 4.5 years of age.

Results

In the data analysis all t-tests were two-tailed, unless otherwise noted. The magnitude of the effect or effect size is

reported as Cohen's d . Cohen's d expresses effect size in standard deviation units (Rosenthal & Rosnow, 1991). Analyses reported as product-moment correlation coefficient, r , have been transformed to Cohen's d (Rosenthal & Rosnow, 1991) allowing for all measures of effect size to be the same.

Cognitive Sex Differences

There were no differences between males and females on measures of spatial ability (Mazes, Block Design, Puzzles), or on the measure of verbal ability (see table 2). An aggregate spatial score was formed by summing the standardized scores of the three spatial measures. This also showed no significant sex difference.

Insert Table 2 about here

The absence of sex differences is not inconsistent with the existing literature. Huttenlocher and Levine's data showed a male advantage only after 4.5 years. In our data, when the sample was median split for age, older boys did much better than younger boys on the Puzzles task, while older girls and younger girls were roughly equal. Thus, there is evidence that the age period examined in this study is the period immediately preceding the emergence of the spatial sex difference.

Sex Differences in Activities

As would be expected, males spent a significantly higher

percentage of time in activities classified as masculine ($M = 27\%$) than did females ($M = 12\%$), $t(49) = 6.74$, $p < .0001$, $d = 1.93$, and females spent a significantly higher percentage of time engaged in activities classified as being feminine ($M = 12\%$), $t(49) = 6.38$, $p < .0001$, $d = 1.82$, than males ($M = 2\%$). Compared to males ($M = 10\%$), females ($M = 16\%$) spent a higher percentage of time doing neutral activities, $t(49) = 2.16$, $p < .04$, $d = .62$.

As hypothesized, there was a sex differences for males in percentage of time spent in spatial activities (M for males = 25% , M for females = 20%), $t(49) = 1.92$, $p < .03$ (one-tailed), $d = .55$.

Correlation of ability and activities

There was a significant positive correlation between percentage of time spent participating in neutral activities and the standardized spatial score, for both males, $r(25) = .46$, $p < .02$, $d = 1.03$, and females, $r(20) = .43$, $p < .05$, $d = .95$. For females, there was also a significant negative correlation between percentage of time spent on masculine activities and the standardized spatial score, $r(20) = -.60$, $p < .005$, $d = 1.52$ (see table 3).

Insert Table 3 about here

Because females participated more than males in activities rated neutral by undergraduates, and neutral activities were

associated with higher scores on the spatial composite, we examined whether sex differences on verbal and spatial measures might appear with activity preferences controlled. An analysis of covariance was conducted where masculine, feminine, and neutral were entered as covariates. However, no significant sex differences on verbal and spatial measures emerged.

The composite spatial score represents, in all likelihood, a more reliable and valid indicator of spatial ability than any single measure. We also examined the correlations of activity with individual tests. Table 3 shows that the general pattern of the correlations is consistent with that found using the composite score. In particular, all correlations involving neutral activity are positive, although none is significant, and correlations with masculine activity for females are all negative, with one individually significant. In addition, for males, there was a significant negative correlation between masculine activity and Block Design, $r(21) = -.49$, $p < .01$, $d = 1.14$. The only correlation involving feminine activity was that, for females, there was a significant negative correlation between feminine activities and Mazes, $r(21) = -.57$, $p < .005$, $d = 1.39$.

No correlations were found for males or females between the spatial measures and percentage of time spent on activities categorized as spatial or non-spatial (Range of r 's $-.40$ to $.25$).

Correlation of ability with T.V. and Reading by Sex

There were no significant correlations for either males or females between percentage of time spent reading (or being read to by an adult) and measures of spatial and verbal ability (range of r 's was $-.34$ to $.34$). Nor were the cognitive measures correlated with percentage of time watching television (range of r 's was $-.19$ to $.32$).

Discussion

The most interesting finding of this study was the positive relation between percentage of time spent doing neutral activities (e.g., art activities, boardgames, swimming, puzzle/mazes, junglegym/swingset, hide and seek) and the standardized spatial score for both males and females. The data did not replicate Connor and Serbin's (1977) report that, for males, masculine activities (e.g., building activities, vehicles) were positively related to spatial ability. In fact, the opposite was observed for females.

One might argue that the explanation for this discrepancy could be the environments where activity preferences were measured. Connor and Serbin observed activity preferences during play-time at a preschool, whereas we observed activity preferences in and around the home. Due to peer pressure, children (especially boys) who prefer neutral activities at home may exhibit more stereotyped behaviors at nursery school (Fagot, 1977). However, it is difficult to imagine that this would be differentially true for boys strong in spatial skills, to the

extent that one would find spatial ability correlated with masculine activity in preschool and neutral activity at home. Nor would the contrast in setting account for the findings for girls, who have considerably more latitude than boys in terms of peer pressure for sex-typed play.

A different reason for the contrasting findings maybe the fact that, unlike Connor and Serbin, we included a category of neutral activities. That is, Connor and Serbin did not examine the relation for which we found most support. Of course, this does not explain why masculine activity was not correlated with spatial ability in our sample of boys, and was significantly negatively correlated for girls.

One interpretation of the correlation with neutral activities focusses on the fact of what they are not. For preschoolers, much of the play that is sex-typed masculine involves large-muscle, rough-and-tumble play revolving around fantasied or real conflict and dominance. A child with such concerns may find it more difficult to focus on the sustained cognitive effort required to do well on the spatial tasks. On the other hand, much of the play that is sex-typed feminine involves themes of fantasied nurturance and social interaction. A child with such concerns may be able to concentrate on tasks, but may lack the intellectual assertiveness required to persist in effort on problems that become harder and harder.

Researchers who study gender stereotyping in self-concept

and cognitive performance (e.g., Bem, 1981; Nash, 1979; Signorella & Jamison, 1986) may find our results of interest. Traditionally, gender self-concept has been thought of as masculine, feminine, or androgynous. An individual having an androgynous self-concept has been defined as having, high scores on measures of both masculinity and femininity, or sometimes, as having relatively equal scores on both masculine and feminine measures. However, for preschoolers at least, an androgynous self-concept may be defined in terms of gender-neutral traits and activities. Prior findings of no association of spatial ability with androgyny (as defined by personality trait measures, for older children and adults) (Signorella & Jamison, 1986) may not hold true for preschoolers, given an age-appropriate redefinition of androgyny. In light of our findings, researchers may want to consider defining an androgynous self-concept in terms of gender-neutral traits and activities.

Our results do not show participation in spatial activities such as building blocks (e.g., legos), vehicles, puzzles, and mazes to be related to measures of spatial ability for either preschool males or females. This finding fails to support Sherman's hypothesis (Sherman, 1967) that participation in these activities would facilitate visual-spatial abilities. In interpreting this result, it is important to note how little time preschoolers spent on these visual-spatial activities. In our study, boys and girls on average spent only 4 percent of their

time playing with building blocks, legos, puzzles, and mazes. It seems somewhat surprising how much prominence these activities are given in psychologists' discussions considering how infrequently they are done at home. It may be time to reexamine our understanding of the type of activities which relate to spatial ability, as well as the context in which they take place.

Let us consider the implications of the present findings for theories of the origin of sex differences in spatial ability. First, with respect to the role of prenatal androgens, there is evidence from studies of females suffering from chronic adrenal hyperplasia that higher levels of prenatal androgens are associated with higher levels of spatial ability (Resnick et al., 1986) and also with higher masculine and lower feminine toy preferences (Berenbaum & Hines, 1992). This raises the clear possibility that the influence of prenatal androgens on toy preferences mediates and causes the influence on spatial ability. Such a hypothesis is contradicted, however, by the present data, which suggest that the two effects may be parallel and unrelated.' Preference for neutral play activities, unrelated to prenatal hormone status in Berenbaum and Hines' data, would thus be a source of within-sex rather than between-sex variance.

Second, with respect to either straightforward environmental hypotheses or "bent twig" account, the present findings suggest that sex-typing of activities is not likely to play a large part in the origin of spatial sex differences. However, a very

different "bent twig" account, developed by Casey, retains promise. Casey has presented evidence that females who are left-handed or have left-handed relatives show more effect of engagement in spatial activities than other females. This suggest that a preference for holistic spatial strategies can be developed (or not) by opportunities and choices to engage in spatial activity. Again, variations in activity would, however, contribute more to explaining within-sex than between-sex variation.

In summary, neutral activities were positively related to a standardized spatial score for both males and females. This is in contrast to those researchers who assert masculine activities are positively related to spatial ability. If substantiated, such a pattern of findings has important implications for theories of the causes of both individual and sex-related differences in spatial ability.

Table 1

Listing of Activities Categorized as Spatial, Non-Spatial,
and Rated as Masculine, Feminine, and Neutral.

	<u>Spatial</u>	<u>Non-Spatial</u>
<u>Masculine</u>	Building Activities, Vehicles Video Games, Riding Bikes/ Bigwheels, Sports, Playing Ball	Action Figures, Running Around, Indoor Action Games, Toy Dinosaurs, Male Pretend Play
<u>Feminine</u>	Setting a Table	Female Pretend Play, Help with Cleaning, Playing Barbie, Playing House, Playing with Dolls, Help with Washing, Playing Tea Party, Help with Clothes, Help with Caring for Siblings
<u>Neutral</u>	Art Activities, Puzzle & Mazes Where's Waldo, Play-dough, Hide and Seek	Swimming, Boardgames, SwingSet/ Jungle Gym, Listening to Music, Music Lessons, Playing Tag, Sandbox Play, Neutral Pretend Play, Walking a Pet, Catching Bugs, Bathing, Blowing Bubbles

Table 2

Means and Standard Deviations of Spatial and Verbal Measures by Sex

<u>Measure</u>	<u>Male</u>		<u>Female</u>		<u>t</u>	<u>p</u>	<u>d</u>		
	<u>Mean</u>	<u>(SD)</u>	<u>n</u>	<u>Mean</u>				<u>(SD)</u>	<u>n</u>
Vocabulary	13.00	(3.14)	29	14.10	(2.87)	29	1.33	.18	.36
Puzzles	11.62	(4.70)	29	13.44	(4.72)	27	1.45	.15	.39
Mazes	11.86	(2.34)	29	11.04	(2.17)	28	1.38	.17	.37
Block Design	11.17	(2.97)	29	11.83	(2.48)	29	.91	.36	.24
Summed Spatial	-0.18	(2.30)	29	0.30	(2.24)	27	.80	.42	.22

Table 3

Relation Between Feminine, Masculine and Neutral Activities and Spatial and Verbal Measures

<u>Measure</u>	<u>Sex</u>					
	<u>Male (N=27)</u>			<u>Female (N=22)</u>		
	<u>Feminine</u>	<u>Masculine</u>	<u>Neutral</u>	<u>Feminine</u>	<u>Masculine</u>	<u>Neutral</u>
Vocabulary	.29	-.08	.09	.15	.07	.01
Puzzles	-.06	-.02	.25	.00	-.53*	.34
Mazes	.07	-.30	.21	-.57**	-.19	.20
Block Design	-.19	-.49*	.19	-.23	-.21	.10
Summed Spatial	-.17	-.20	.46*	-.08	-.60**	.43*

* $p < .05$ ** $p < .01$

Footnotes

- ¹ Waber (1977) had suggested that hormonal factors may possibly influence brain lateralization during pubertal maturation. Recently, however, this theory has been criticized by those who have observed differences prior to puberty (Kerns & Berenbaum, 1991) as well as by negative findings on the relation of timing of puberty and spatial ability (Newcombe & Dubas, 1987, 1992).
- ² These percentages do not sum to 100%. Additional activities were: television (males = 22%, females = 20%), reading (males = 4%, females = 5%), undetermined or adult-directed activities (e.g., visiting a friend, going to the supermarket, males = 23%, females = 22%), and rare activities not rated for sex-typing by undergraduates (males = 11%, females = 13%). In correlational analyses reported below, we excluded undermined and unclassified activities from consideration.
- ³ Or, even, it may be that the increase in masculine toy preferences reduces the prenatal effect of androgens on spatial ability; see our negative correlation between masculine play in girls and the spatial composite.

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